Thermal Conditioning Module for Ultra-High Temperature Applications

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MSFC's Preliminary Design (PD) office, working in conjunction with personnel from its Science and Engineering (S&E) Directorate, completed an in-house feasibility study using solar thermal propulsion as an alternative means for transporting payloads from low-Earth orbit (LEO) to a geosynchronous orbit (GEO). The study found this concept to be technically feasible by the year 2000 and it could "reflect savings of 14 percent to 26 percent over current systems."[1] Due to these results, there has been a great deal of interest in pursuing this concept and several efforts have been funded to pursue the technology to make this concept feasible. The objective of a recent preliminary level one study requirement was to determine the feasibility of using a solar thermal upper stage for delivering payloads (up to 4,000 lb) from LEO to GEO in a reusable-type launch vehicle. The preliminary design configuration of the vehicle can be seen in figure 73. For the design effort, this report is written to identify one of the technology issues which needs to be addressed.

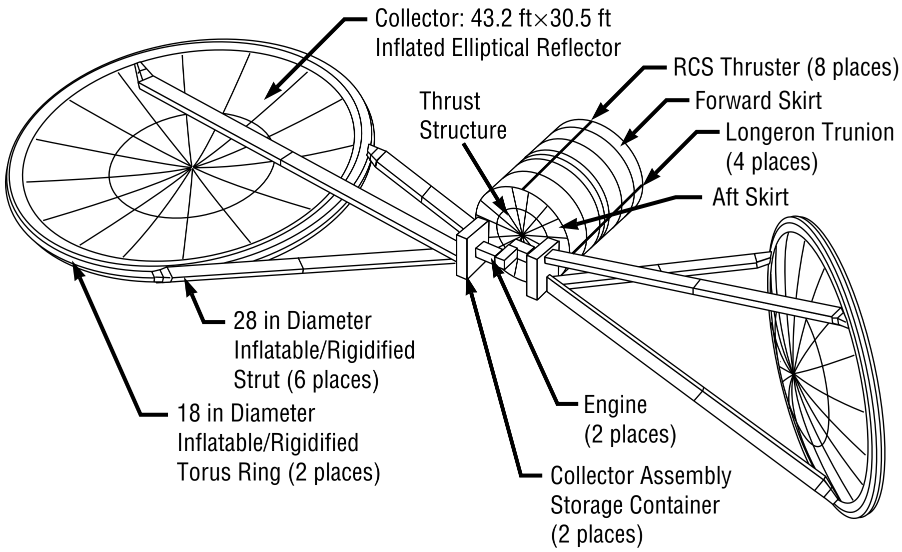

FIGURE 73.—A deployed configuration of a solar thermal upper stage vehicle.

The thermal study[2] performed on the solar energy engine absorber for the beyond LEO advanced space transportation study (BLAST) revealed the following:

- Temperatures of the absorber were driven to the desired operating temperature of 4,500 °F by all four collector sizes. The rates at which an absorber can reach the operating temperature rely on a solar energy magnitude concentrated at the aperture.
- The steady-state temperatures exceeded the absorber tungsten housing melting temperature of 6,000 °F. In the case which simulates the actual expected operations, a thermal conditioning module (TCM) is required to adjust the heating once the absorber reaches the operating temperature of 4,500 °F to achieve the rapid charge time of the larger concentrator, and to constantly keep the absorber at the operating temperature prior to an engine thrusting process.

The TCM is a unit that can process the temperature measurements from an ultra-high temperature measurement device. This device can measure the temperature of the absorber using a noncontact or contact method. Then the TCM (with a built-in ultra-high temperature data processor) can also command a device that adjusts the heat input to the absorber. This can be accomplished by several techniques (e.g., changing position of the concentrator relative to the Sun). The temperature measurement devices that can be used for this application are:

- The noncontact method: Optical pyrometer for high-temperature application (this type device is available for testing); or
- The contact method: Thermocouples which are made of metals having high melting temperatures and electrical conductive characteristics (these devices are not currently identified and need to be studied, developed, and tested.

The TCM can be made as a compact unit. A possible system configuration is sketched in figure 74. This approach should improve performance for such ultra-high-temperature applications as the concentrated solar

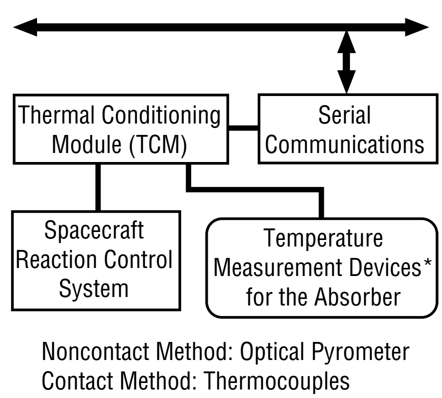

FIGURE 74.—Thermal conditioning module system function schematic.

energy absorber/heat exchanger for the BLAST solar thermal upper stage engines. The TCM holds even greater potential for use in interplanetary travel vehicles. The TCM should provide spacecraft a wider range of trajectories, mission profiles, and scientific objectives. Further potential industry applications include concentrated solar furnaces for material processing/ synthesis, and high solar concentration devices for advanced medical research.

[1]Van Dyke, M.: "Beyond LEO Advanced Space Transportation Solar Thermal Upper Stage Report." PD21 (96–06), Marshall Space Flight Center, September 3, 1996.

[2]Nguyen, D.: "Thermal Analysis of the Solar Thermal Engine Absorber for the Beyond LEO Advanced Space Transportation (BLAST)." ED63 (22–96), Marshall Space Flight Center, July 5, 1996.

Sponsor: MSFC's Preliminary Design Office

Biographical Sketch: Dalton Nguyen has a B.S. in mechanical engineering and works as a thermal engineer in the Structures and Dynamics Laboratory where he has been a member of the Engine and Propulsion Systems Team of the Thermal and Life Support Division since 1987. His contributions are in support of the Shuttle elements, Reusable Launch Vehicle programs including X–34 and X–33, new technologies such as the vacuum plasma spay processing, DC–XA liquid propulsion systems, and concentrated solar thermal energy propulsion programs.